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Nematodes and Cestodes from the Australian Monitor, *Varanus gouldii*

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(Text-figures 1-6)

The parasites reported here were taken from the digestive tract of a lizard, *Varanus gouldii* (Gray), which died November 10, 1959, in the New York Zoological Park. The animal, a mature male, was 1.58 meters long and weighed 7.8 kilograms. It was taken near Karumba, on the lower Norman River, North Queensland, June 21, 1959. When captured, it was eating a salt-water crocodile, *Crocodylus porosus*. *Varanus gouldii* is a terrestrial species which inhabits the arid interior areas of Australia.

Autopsy revealed several hundred nematodes with their anterior ends deeply embedded in the mucosa of the stomach. The stomach wall was greatly thickened and dark purple in color. The initial portion of the intestine, just beyond the stomach, contained about a dozen tapeworms with their scolices deeply embedded in the mucosa. In this area there were also several yellowish scars in the mucosa, presumably from the detached tapeworms. There was general peritonitis throughout the abdominal cavity. The liver was extremely swollen, with fibrinous deposits over the external surface. It contained numerous deep necrotic abscesses, which were light tan in color in contrast to the normal, red-colored tissue. Beginning about 10 cm. from the anus, the intestine was much distended for some 5 cm. and, on section, this region showed numerous scars in the mucosa with necrosis and sloughing.

Tanqua tiara (von Linstow, 1879) Blanchard, 1904

The nematodes are identified as *Tanqua tiara*, a species described by von Linstow (1879) as *Ascaris tiara* from *Varanus ornatus* in Natal, South Africa.

Linstow (1904a) erected the genus *Ctenocephalus* to contain *A. tiara*, and in the species he included worms from *Varanus bengalensis* taken in India and from *Varanus salvator*, a widely distributed lizard found in southeast Asia, Ceylon and the islands of the East Indies. Blanchard (1904) noted that *Ctenocephalus* von Linstow was a homonym of *Ctenocephalus* Kolenati, 1857, a genus erected to contain the siphonapterous species, *hyanae*, *canis*, *felis*, etc., and he renamed the genus *Tanqua*, with *tiara* as type species.

Meanwhile, Stiles had informed von Linstow that the name *Ctenocephalus* was preoccupied, whereupon von Linstow (1904b) substituted the name *Tetradenos* which, published later, became a synonym of *Tanqua*. The nomenclatorial combination, *Tanqua tiara*, was made by Stiles & Hassall (1905). Parona (1898) reported *Ascaris tiara* from *Varanus salvator* taken in Sumatra and from *Varanus gouldii* taken in Australia or New Guinea—the locality was not definite. Leiper (1909) identified worms from *Varanus niloticus* taken on the White Nile as *T. tiara*. Baylis (1916) suggested that the specimens described by von Linstow were from *Varanus albigularis*, rather than *V. ornatus*. He emended and amplified the earlier descriptions of *T. tiara*; to this species he assigned specimens from *V. niloticus* taken at Accra on the African Gold Coast, from *Varanus exanthematicus* taken in northern Nigeria, from *Tropidonotus quincunciatus* (= *T. asperrimus*) taken in Ceylon, and others from an unnamed species of *Varanus* taken in Zanzibar.

Baylis transferred *Heterakis anomala* von Linstow, 1904, from the stomach of *Tropidonotus piscator* taken in Ceylon, to *Tanqua* as *T. ano-*

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mala (von Linstow) and described as *T. diadema* n. sp., specimens from the South American freshwater snake, *Helicops angulatus*. *Tanqua diadema* was distinguished by the shorter length of the esophagus and the more anterior location of the vulva. *Tanqua anomala* is a large species and like *T. diadema*, has an anterior vulva.

The specimens from *V. gouldii* agree so completely with Baylis's definition of *T. tiara* that their allocation is readily made.

Tanqua tiara is one of the gnathostomes, spirurid nematodes, in which typically the life-cycle involves three hosts, a crustacean, a fish or amphibian and the final vertebrate host, although in certain species with hard-shelled, embryonated eggs, a terrestrial arthropod may serve as the single intermediate host. In *T. tiara* the eggs are thin-shelled. According to Mönnig (1947), juvenile worms migrate in the abdominal organs, particularly the livers of their final hosts. In passing through the liver, they destroy tissue and leave characteristic yellow mosaic markings on the surface and burrows filled with necrotic material in the parenchyma. They wander through other organs, including the diaphragm. Adult worms penetrate the wall of the stomach, producing cavities filled with sanguino-purulent fluid and a marked gastritis.

Bothridium parvum (Johnston, 1913)

The cestodes from *V. gouldii* belong to the genus *Bothridium* de Blainville, 1824, whose members are parasitic primarily in pythons and boas. The type species is *B. pithonis* de Blainville, 1824, from the intestine of *Python molurus*, although de Blainville (1828) stated that the parasite occurred also in other pythons.

Joyeux & Baer (1927) gave a historical review of the genus and the species from snakes which had been assigned to it. They suppressed *Prodicoelia* Leblond, 1836, and *Solenophorus* Creplin, 1839, as synonyms of *Bothridium*. *Prodicoelia* was based on *P. ditrema* Leblond, 1836, from the South American anaconda, listed as *Boa scytale* (=*Eunectes murinus* Wagl.). Joyeux & Baer recognized *B. ditremum* (Leblond, 1836) and two species from African and Asian pythons, together with a smaller variety of the Asian species. The African species was identified as *B. ovatum* (syn. *Solenophorus ovatus* Diesing, 1850) from *Constrictor hieroglyphicus* (= *Python sebae* Kuhl.). The larger Asian specimens were assigned to *B. pithonis* de Blainville, 1824, and the smaller worms from *Python reticulatus* Gray were described as *Bothridium pithonis* var. *parvum* nov. var. Joyeux & Houdemer (1928) listed both *B. pithonis* and *B. pithonis* var. *minor* Joyeux & Baer, 1926, from the intestine of *Python reticulatus*. In addition to pythons and boas, *B. pithonis* was reported from the king cobra of Malaya, *Naja hannah*, by Loewen (1945) and Yeh (1956).

Species of *Bothridium* have been described also from varanid lizards. Valenciennes (1850) recorded an unnamed species from *Varanus niloticus*. Johnston (1913) described specimens from *Varanus varius* taken in North Queensland as *Bothridium pythonis* var. *parva* var. nov. and later (1916) he listed these worms as *Bothridium parvum*. Notified of the homonomy of *B. pithonis* var. *parvum* Joyeux & Baer, 1927, and *B. parvum* (Johnston, 1913), Joyeux & Baer (1928) proposed the name *B. pithonis* var. *minor* to replace *B. pithonis* var. *parvum*. They followed de Blainville in writing the specific name *pithonis*, although they stated that correct transliteration would be spelled, *pythonis*. Certain authors including Monticelli & Crety (1891) and Johnston (1913) have used the correct orthography. Baylis (1935) noted that the name given by Joyeux & Baer (1927) was *B. pithonis* var. *parvum*, not *B. pithonis* var. *minor* Joyeux & Baer, 1926, as stated by Joyeux & Houdemer (1928). Baylis observed that the specific name, *minor*, is available to distinguish between the specimens studied by Joyeux & Baer and those of Johnston. Joyeux & Baer (1936) admitted that the specimens named *B. pithonis* var. *minor* are identical with those named earlier *B. pithonis* var. *parvum;* that the latter name disappears as a homonym and the correct designation is *B. pithonis* de Blainville, 1824; var. *minor* Joyeux & Baer, 1928.

The descriptions of *B. parvum* and *B. pithonis* var. *minor* are so brief and inadequate that satisfactory comparisons between them and the present specimens can not be made. Johnston (1913) noted differences in the form of the bothria as a result of muscular contractions and that the relative thickness of the ring of longitudinal muscles varies inversely with the elongation of the proglottid, so certain measurements that appear precise may have little value. The form of the ovary, especially its anteroposterior extension, may change as the proglottid is relaxed or compressed by contraction of the longitudinal or transverse muscles. Since the descriptions of the species named above are so inadequate, it appears worth while to present a more complete account of the worms from *V. gouldii*. They agree most closely with *B. parvum* and, although somewhat larger, are tentatively assigned to that species.

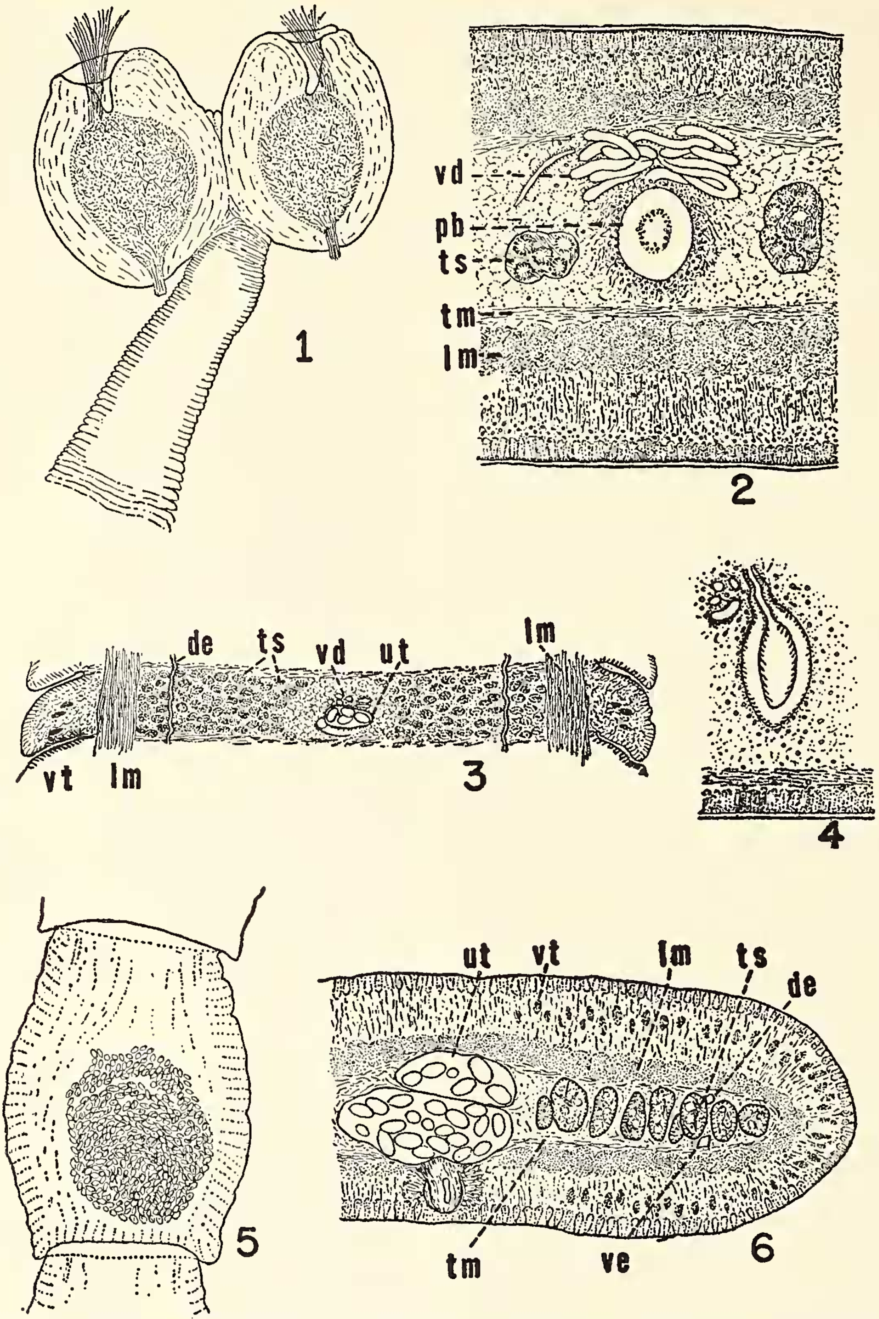
It is noteworthy that *V. varius*, host of *B. parvum*, is an arboreal species of rain-forests whereas *V. gouldii* lives in very dry interior areas and does not climb trees. The differences in locality and ecology, together with difficulties the parasite would encounter in transferring from one area to the other, suggest distinct species of *Bothridium,* but clear-cut specific differences are not apparent. Furthermore, two possibilities exist to account for the same species in different hosts and climatic regions. The species of *Varanus* are carnivorous and an intermediate host containing the larvae may migrate seasonally or otherwise between desert and rain-forest regions. Mertens (1942) reported that monitors feed on other lizards, on birds and many types of animals; also that a specimen of *V. salvator* 1.65 m. long was found in the stomach of *Python reticulatus,* 3 m. long. Thus the parasites of each species are introduced into the digestive tracts of their predators. Another possibility presupposes that a common ancestor of the two varanids may have harbored the cestode which has persisted in the existing species without specific change. The problems of specific determination and intraspecific variation in parasitic flatworms were discussed by Stunkard (1957).

The specimens from *V. gouldii* measure as much as 75 mm. in length and 2.5 mm. in greatest width, with scolices so deeply embedded in the intestinal wall that they could be removed only when released by dissection of the surrounding tissue. When pulled free, the bothria were filled with tissue of the host and bundles of fibers protruded from the anterior openings (Text-fig. 1). The scolex measures 3.0-3.4 mm. in the dorsoventral axis; the bothria are 2.1-2.4 mm. long and 1.45-1.75 mm. in width. The strobila is craspedote and a stained, mounted specimen 68 mm. long comprises 244 proglottids. The original terminal proglottids had been lost. There is virtually no unsegmented neck region; the proglottids increase in size and after one-fifth of the total length, the sides are almost parallel. The reproductive organs mature early and by proglottid 150, one-fourth of the length from the scolex, proglottids measure 1.80 mm. in width, 0.20-0.27 mm. in length, and eggs are beginning to appear in the uterus. Further back in the strobila the proglottids become more elongate and the one before the last (Text-fig. 5) is 1.85 mm. long and 1.30 mm. wide. The reproductive organs have virtually disappeared and it is hardly more than an egg sac.

The excretory vessels and nerve trunks lie in the medullary parenchyma. The two excretory ducts on either side extend the length of the strobila; the dorsal ones are smaller and slightly lateral to the larger ventral vessels which are connected by transverse ducts near the posterior end of each proglottid. The chief longitudinal nerve trunks are situated just lateral to the ventral excretory ducts and ventral to the dorsal excretory vessels.

The testes are arranged in a single, staggered layer, 150-200 follicles in the medullary portion of each proglottid (Text-figs. 3, 6). They extend throughout the length of the proglottid, except in the median field, and in some proglottids there are about as many follicles on the lateral as on the medial sides of the excretory ducts. The follicles are oval, 0.032-0.055 mm. in length and 0.015-0.035 mm. in width, with their length in the transverse axis of the proglottid. Vasa efferentia fuse to form larger ducts which unite and open into a long, much coiled, sperm-filled vas deferens, 0.010-0.015 mm. in diameter (Text-fig. 2), which functions as a seminal vesicle. The vas deferens opens into a structure with thick muscular walls and lined by ciliated epithelium, formerly known as a seminal vesicle or an "Eschtrichtscher Körper," but Fuhrmann (1931) observed that it seldom contains sperm and actually functions in expulsion of spermatozoa. He called it a "Propulsionsblase," literally a propulsive bulb, and in the present worms (Text-figs. 2, 4), it is 0.10-0.15 mm. long and 0.08-0.11 mm. in diameter. The structure is continuous with and followed by the cirrus-sac, 0.15-0.20 mm. in diameter, which contains many cells that appear to be secretory, with ducts to the base of the male papilla. The common genital pore is located medially, on the ventral surface, about one-fourth of the length of the proglottid from its anterior margin and at the level of the posterior edge of the velum of the preceding proglottid. There is a transversely oval genital atrium, lined with cuticula; the opening of the vagina is immediately behind or somewhat lateral to the cirrus-sac.

The vagina extends posteriad from the genital pore, below the uterus and either right or left of the uterine pore; it passes dorsal to the ovary where the posterior end expands to form a diagonally oriented seminal receptacle 0.08-0.12 mm. in length and 0.04-0.06 mm. in diameter. The ovary is reniform to bilobed, situated on the ventral side, near the posterior end of the proglottid. It is 0.30-0.45 mm. wide and 0.05-0.08 mm. in anteroposterior measurement. The lateral portions extend dorsally, forming a depression which is occupied by the seminal receptacle and the anterior portion of the shell-gland. The oviduct arises at the median posterior face of the ovary, curves laterally anteriorly and dorsally, where it receives a duct from the seminal receptacle; it then turns posteriorly and ventrally, receives the common vitelline duct and enters the shell-gland where it coils about and expands to form the ootype. The shell-gland in one series of



TEXT-FIG. 1. Scolex and early proglottids; scolex turned 90 degrees in mounting so the dorsoventral aspect appears in lateral view; fibers from intestinal wall of host in the bothria. TEXT-FIG. 2. Transverse section through the vas deferens and propulsive bulb, showing cortical and medullary parenchyma, longitudinal and transverse muscles and testicular follicles. TEXT-FIG. 3. Frontal section, showing vitelline follicles, longitudinal muscles, dorsal excretory vessels, testes, vas deferens and uterine coils above the ovary. TEXT-FIG. 4. Transverse section through the junction of vas deferens and propulsive bulb. TEXT-FIG. 5. Gravid proglottid, one before the last in a strobila, with accumulation of eggs in the uterus. TEXT-FIG. 6. Transverse section, showing vitellaria, longitudinal, transverse and dorsoventral muscles, testes, excretory ducts, uterus and male papilla. ABBREVIATIONS USED IN FIGURES: **de**—dorsal excretory duct; **lm**—longitudinal muscles; **pb**—propulsive bulb; **tm**—transverse muscles; **ts**—testis follicle; **ut**—uterus; **vd**—vas deferens; **ve**—ventral excretory duct; **vt**—vitelline follicle.

cross sections is 0.024 mm. wide and 0.010 mm. in dorso-ventral extent; frontal sections give an anteroposterior range of 0.010-0.016 mm. From the shell-gland the uterus emerges on the dorsal side of the ovary; it coils ventrally, then dorsally and anteriorly, passing forward on the dorsal side of the proglottid. As it becomes filled with eggs it forms loops (Text-figs. 3, 6), which overlie the ovary and cirrus-sac; the terminal recurrent loop is surrounded by a heavy sphincter and opens at the uterine pore, situated near the middle of the ventral surface of the proglottid. The vitelline follicles lie in the cortical area (Text-figs. 3, 6) and like the testes are interrupted in the median field. They are oval, 0.016-0.035 mm. in length and 0.010-0.022 mm. in width. On either side, ducts from the follicles unite to form larger ducts which pass mediad in the posterior part of the proglottid and join to form the common vitelline duct which opens into the oviduct just before it enters the shell-gland. As the proglottids become gravid, the reproductive organs regress and the uterus becomes a large, egg-filled sac (Text-fig. 5). The eggs are thin-shelled, 0.075-0.080 mm. in length and 0.045-0.050 m. in width.

The life-cycle is not known for any species of *Bothridium* but certain significant data are available. Solomon (1932) obtained development of *B. pythonis* to the procercoid stage in *Cyclops viridis*. Meggitt (1931) reported plerocercoid larvae from the mesentery, lung and aorta of *Naja naja* in Burma. Baylis (1933) found encysted plerocercoid larvae, believed to be those of a species of *Bothridium*, in the liver of a snake (*Bungaris fasciatus*) in Java. Baylis (1935) reported similar larvae from cysts on the external wall of the intestine and mesentery of an Australian water-rat (*Hydromys chrysogaster*) taken at Cromarty, North Queensland. On morphological grounds he assigned the plerocercoids to the genus *Bothridium*, but stated that specific identification is at present impossible. From present data it is probable that crustaceans are the first intermediate hosts and harbor procercoid stages, that fishes serve as second hosts and harbor the plerocercoids which migrate and encyst in the visceral organs of reptiles and small mammals that ingest infected fishes, and that the strobilate stage develops in the final predator.

Summary

Nematodes and cestodes are reported from the digestive tract of a monitor lizard, *Varanus gouldii*, which was captured in North Queensland, Australia, and died in the New York Zoological Park. The nematodes are identified as *Tanqua tiara* (von Linstow, 1879) Blanchard, 1904, and the cestodes are referred tentatively to *Bothridium parvum* (Johnston, 1913) Johnston, 1916, although the description of that species and of *Bothridium pithonis* de Blainville, 1924; var. *minor* Joyeux & Baer, 1928, are so incomplete that final determination is equivocal.

NOTE: Specimens of *Tanqua tiara* and *Bothridium parvum* are in the collection of the American Museum of Natural History, New York.

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